

Single Quantum Dash Mode-Locked Laser as a Comb-Generator in Four- Channel 112 Gbit/s WDM Transmission

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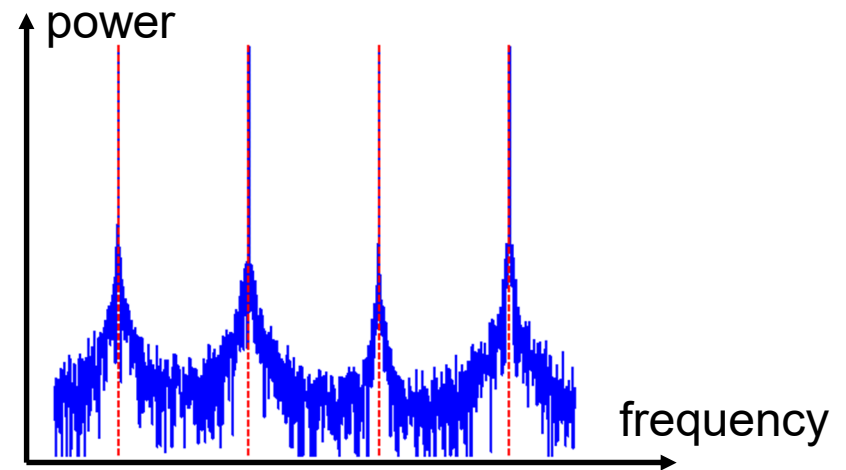
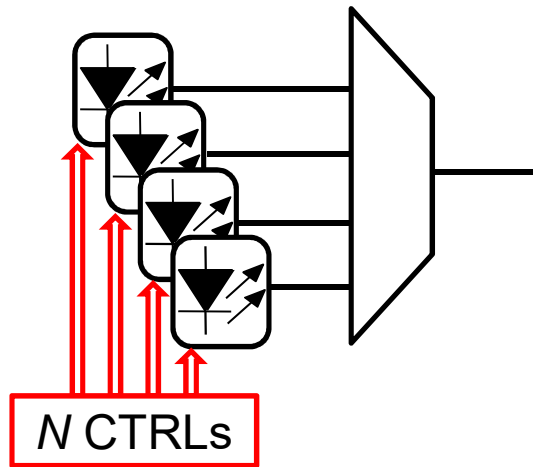
(2) III-V Lab, Marcoussis, France

- 1) Need for low cost transmitters for WDM passive and broadband optical access networks
- 2) Some proposed solutions rely on broadband multi-wavelength sources
 - incoherent \Rightarrow LED, ASE + spectral slicing
 - coherent \Rightarrow (quantum-dot) Fabry-Perot laser diode
- 3) Easier stabilisation of multi-wavelength sources obtained from frequency comb generation

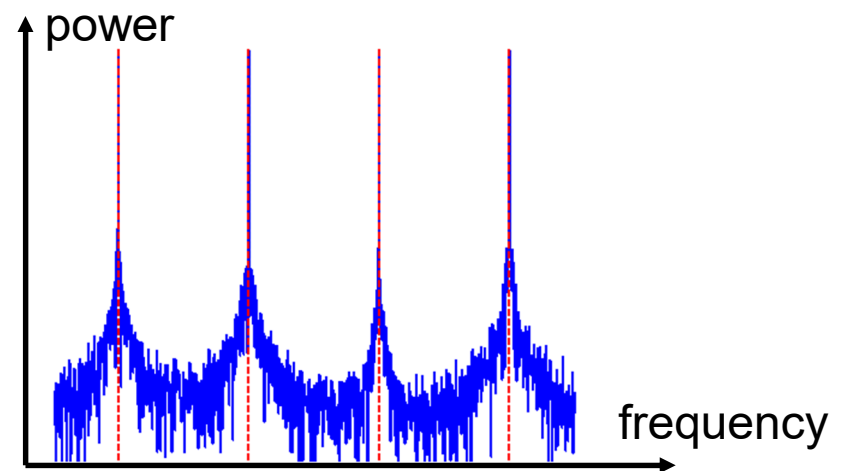
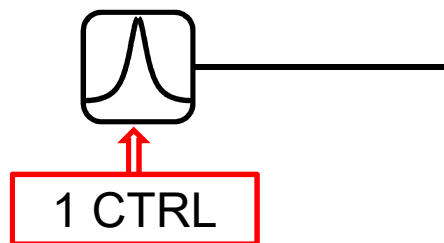
Motivations

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N single wavelength lasers



1 comb generating laser



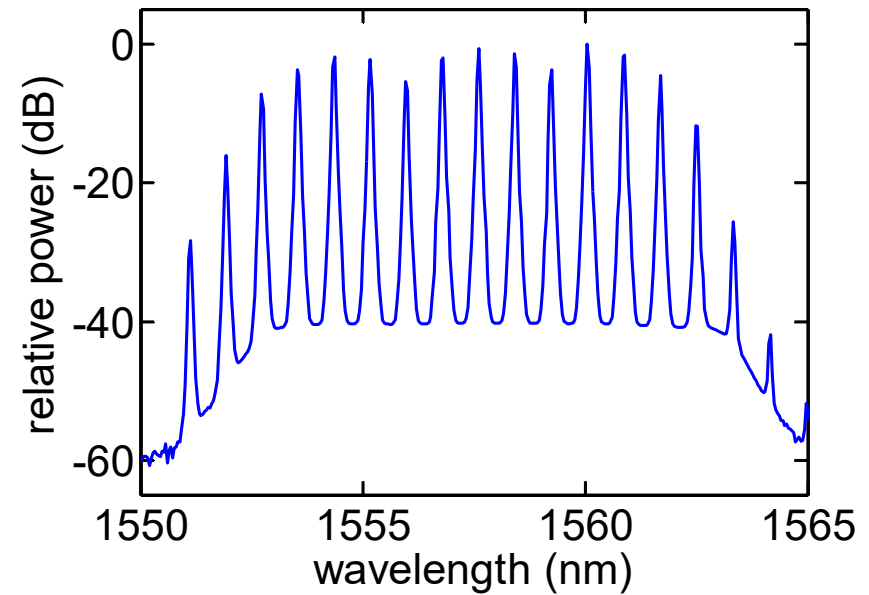
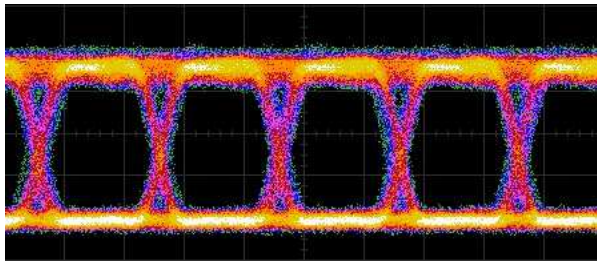
- 1) Need for low cost transmitters for WDM passive and broadband optical access networks
- 2) Proposed solutions rely on spectral slicing of broadband sources
 - incoherent \Rightarrow LED, ASE
 - coherent \Rightarrow (quantum-dot) Fabry Perot laser diode
- 3) Easier stabilisation of multi-wavelength sources obtained from frequency comb generation
- 4) However, major limitation to use of frequency combs generated by Fabry-Perot laser diodes as WDM source is **mode partition noise**

Mode partition noise

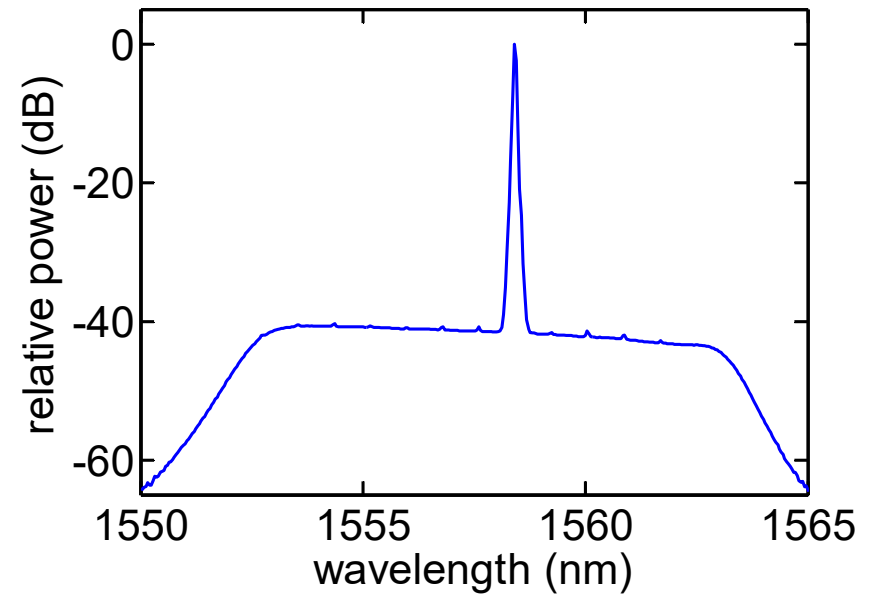
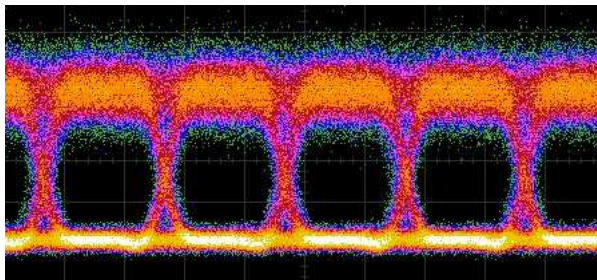
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Output of quantum-dash Fabry-Perot mode-locked laser

All modes



One filtered mode

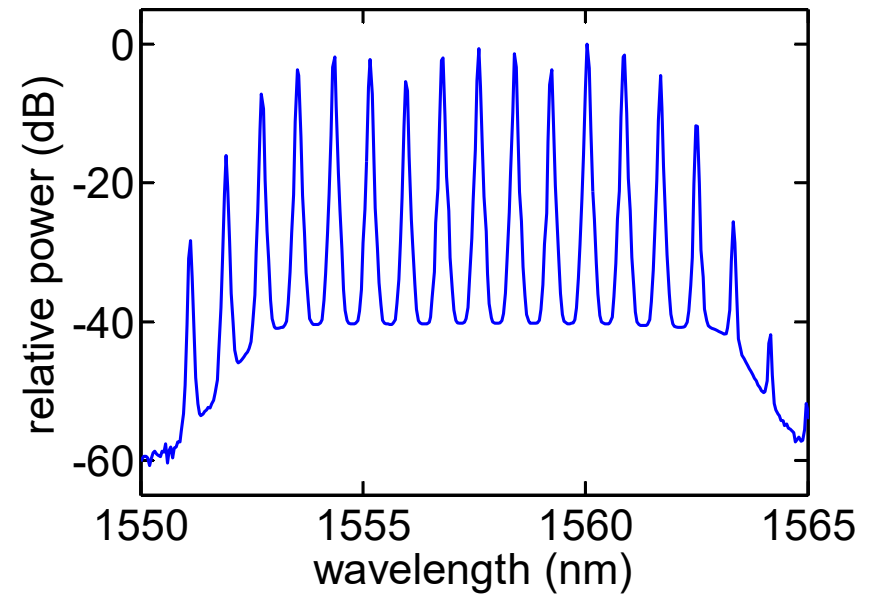
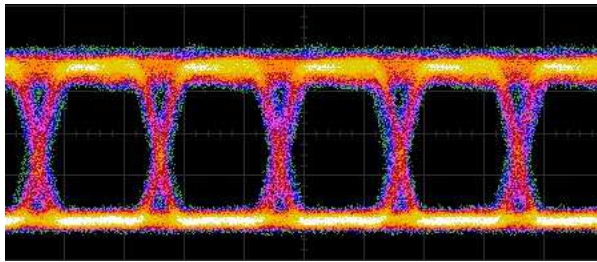


Mode partition noise

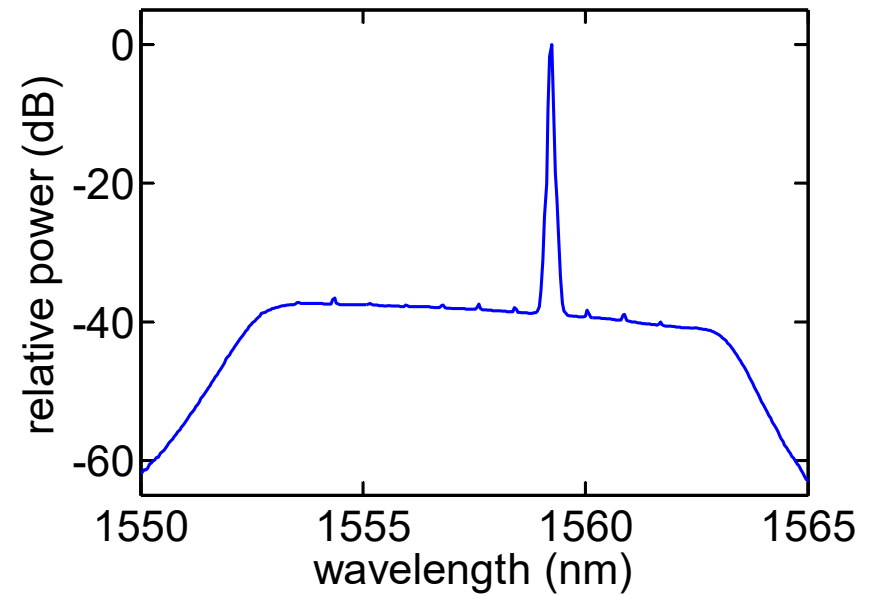
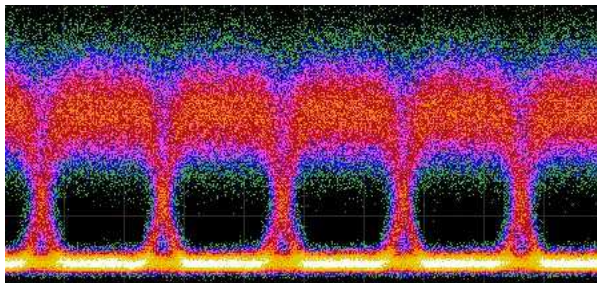
4

Output of quantum-dash Fabry-Perot mode-locked laser

All modes



One filtered mode

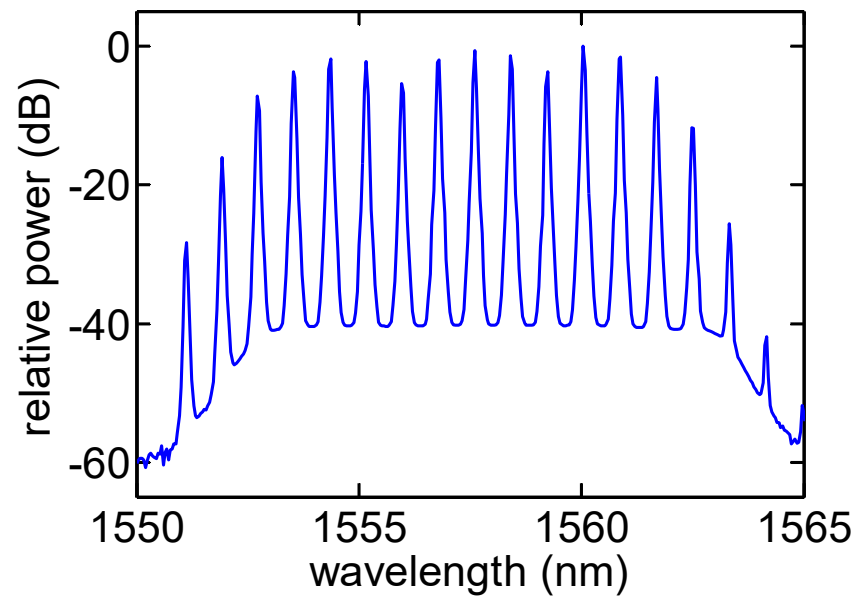
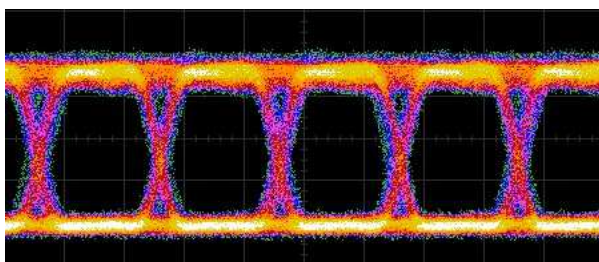


Mode partition noise

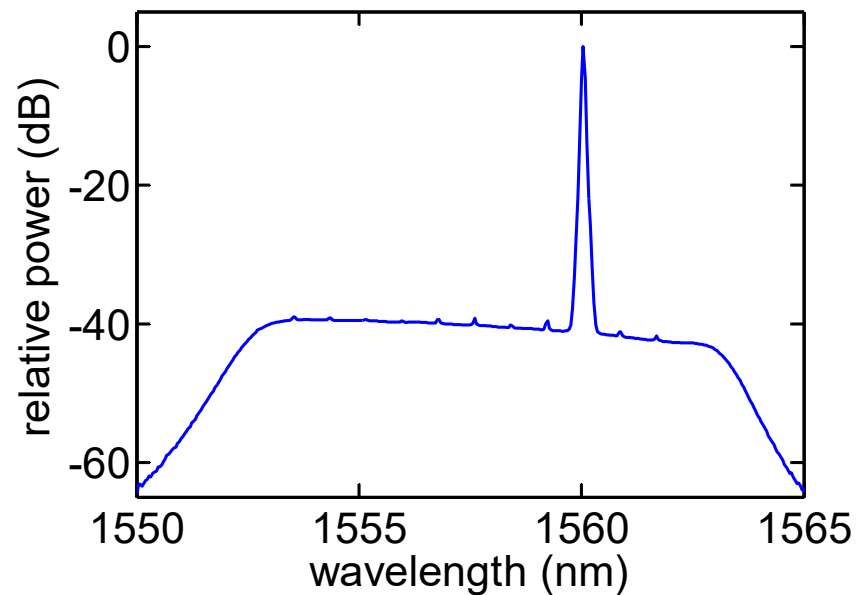
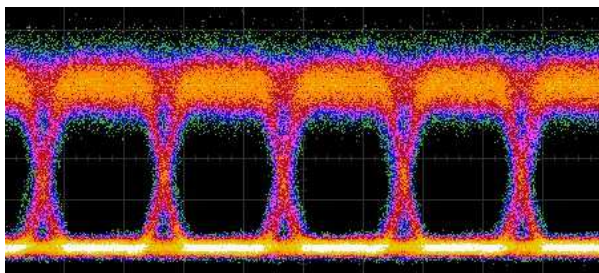
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Output of quantum-dash Fabry-Perot mode-locked laser

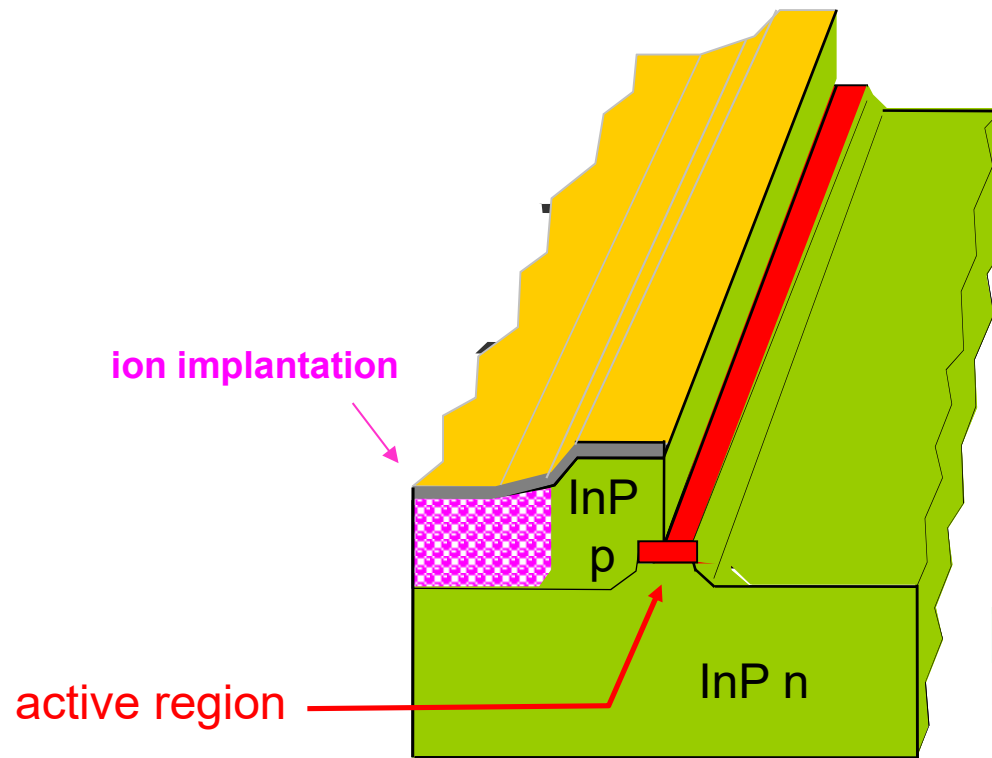
All modes



One filtered mode

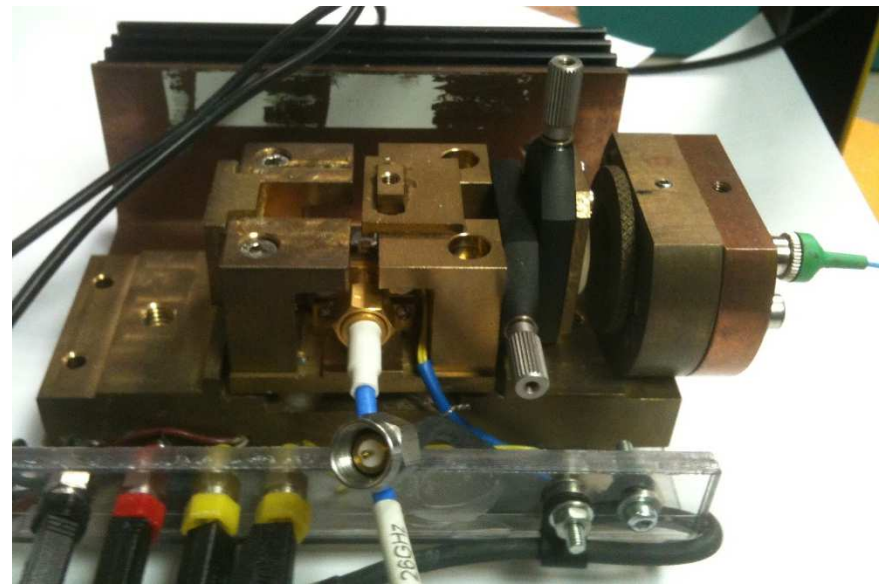


- 1) Motivations
- 2) Quantum-dash Fabry-Perot mode-locked laser
 - Laser structure
 - Frequency comb generation with 100 GHz mode spacing
- 3) RIN suppression using a saturated SOA
 - Principle
 - RIN characterisation
- 4) Transmission of 4×28 Gbit/s over 100 km link
 - BER performance
 - Effect of SOA saturation
- 5) Summary

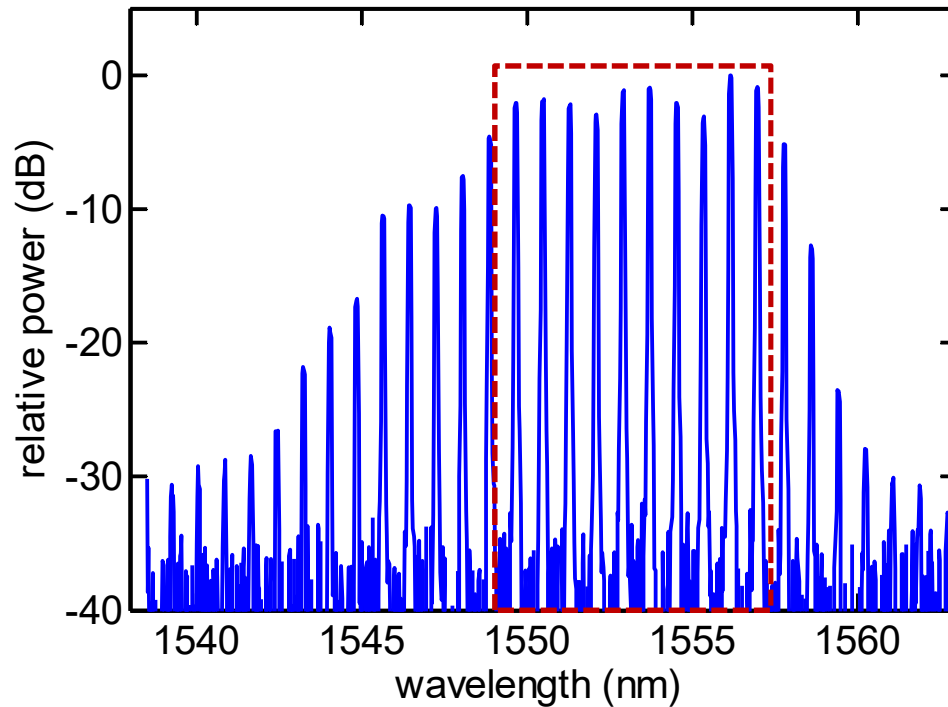


- Buried heterostructure
- **Active region:** InAs quantum dash layers embedded within InGaAsP quantum wells
- Fabry Perot cavity
- Cavity length: 420 μm
⇒ Mode spacing of 100 GHz

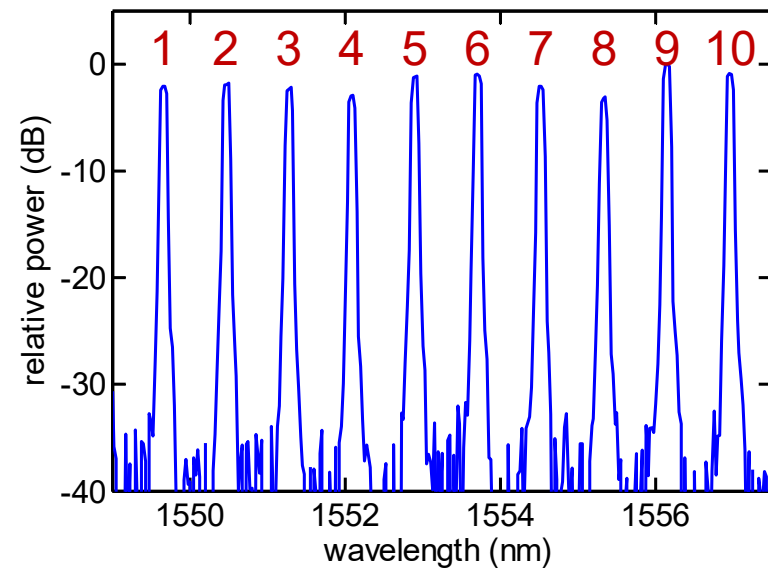
- Laser packaged in a module for coupling stability
- Bulk lenses
- 6 dBm coupled for $I_{\text{bias}} = 150 \text{ mA}$ (22°C)

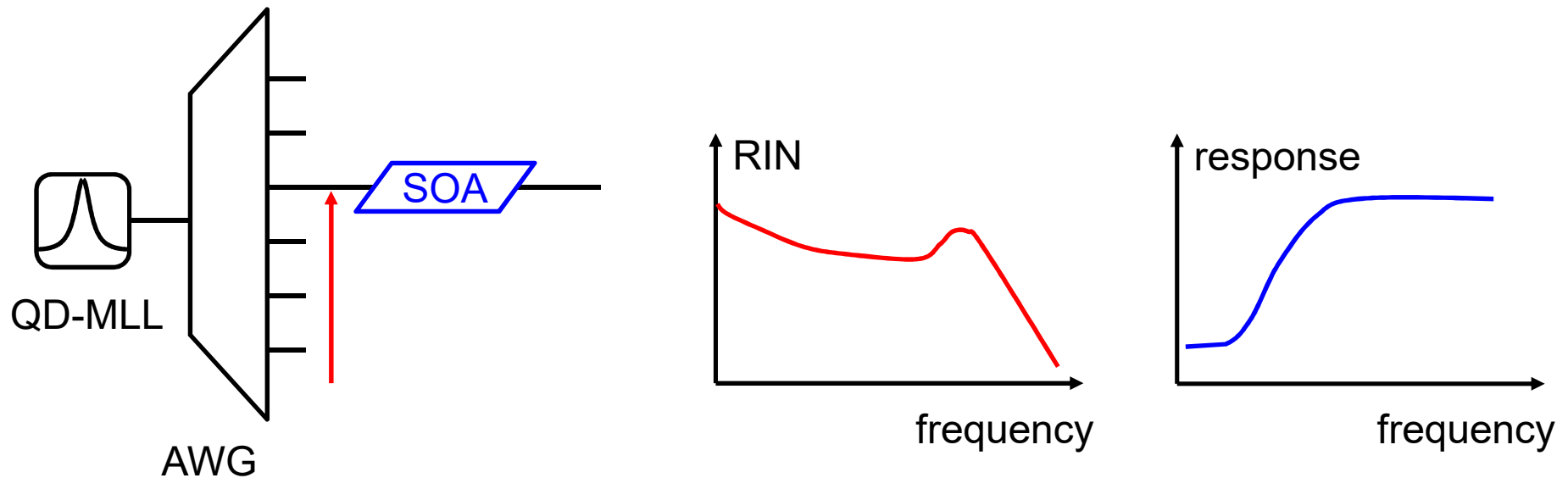


QD-MLL spectrum



- Spectral width at -3 dB: 7.3 nm
- Covers 10 modes spaced by 100 GHz

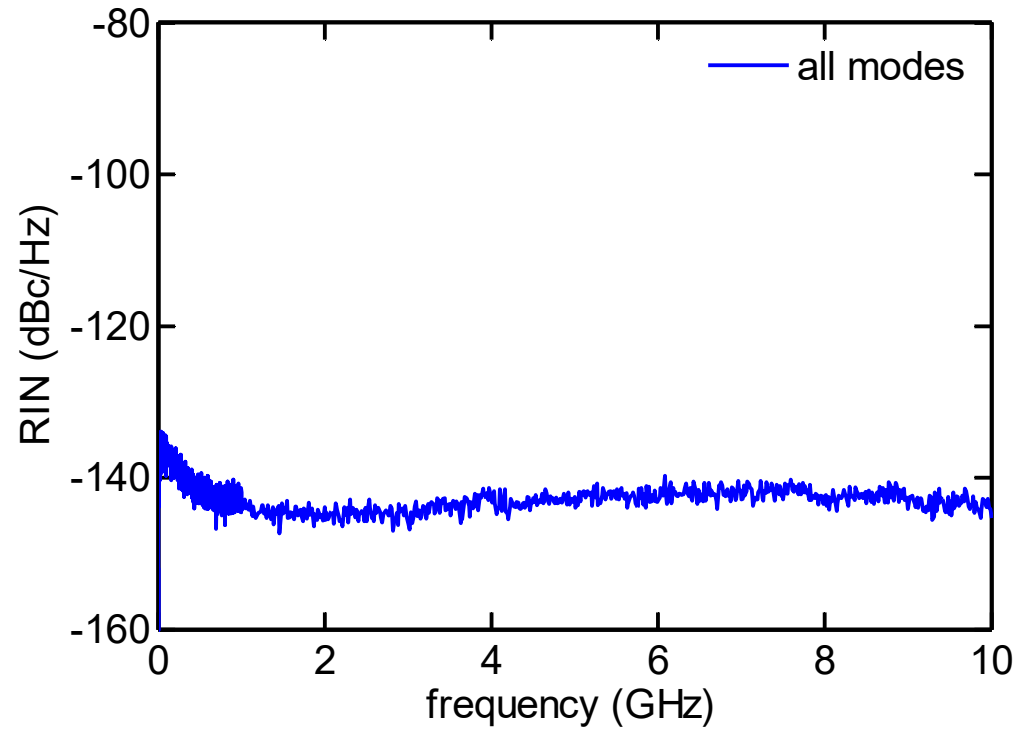
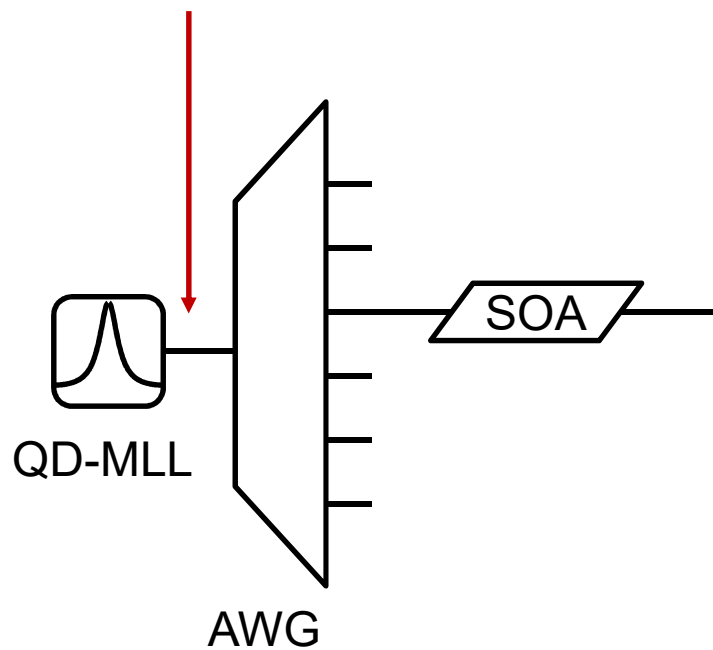




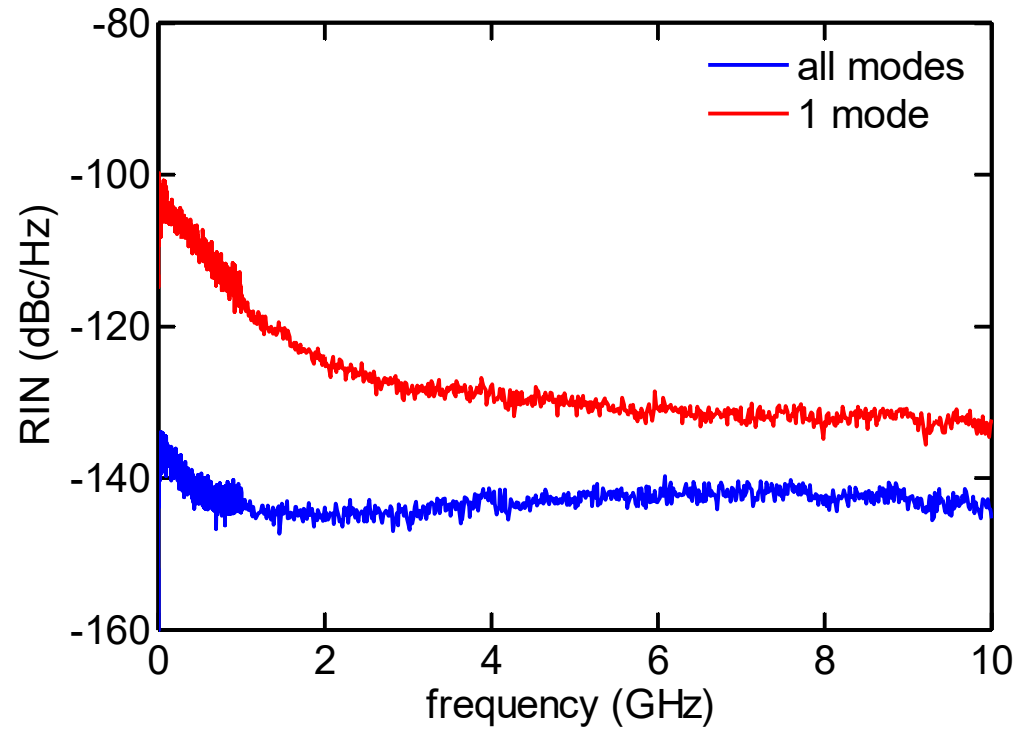
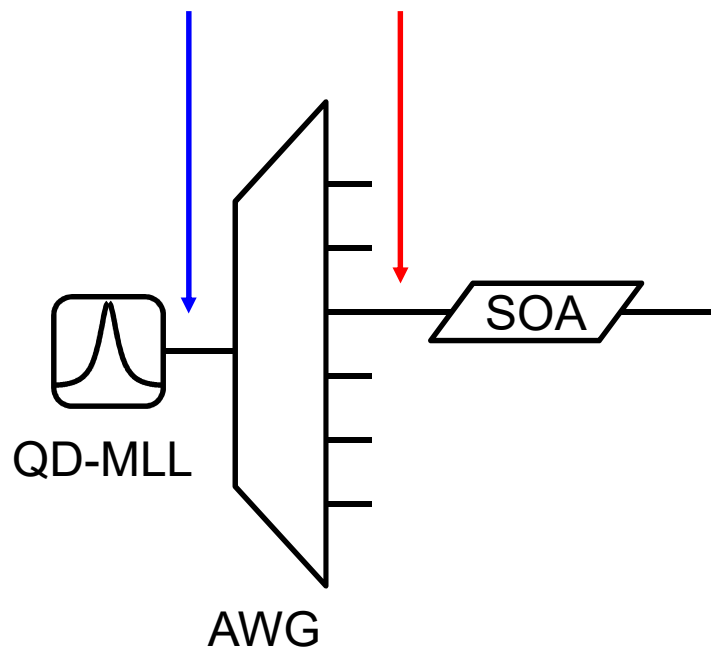
- High-pass filter behaviour of the SOA used to suppress low-frequency RIN
- Effect enhanced by increasing the SOA input power \Rightarrow saturation

SOA used in this work

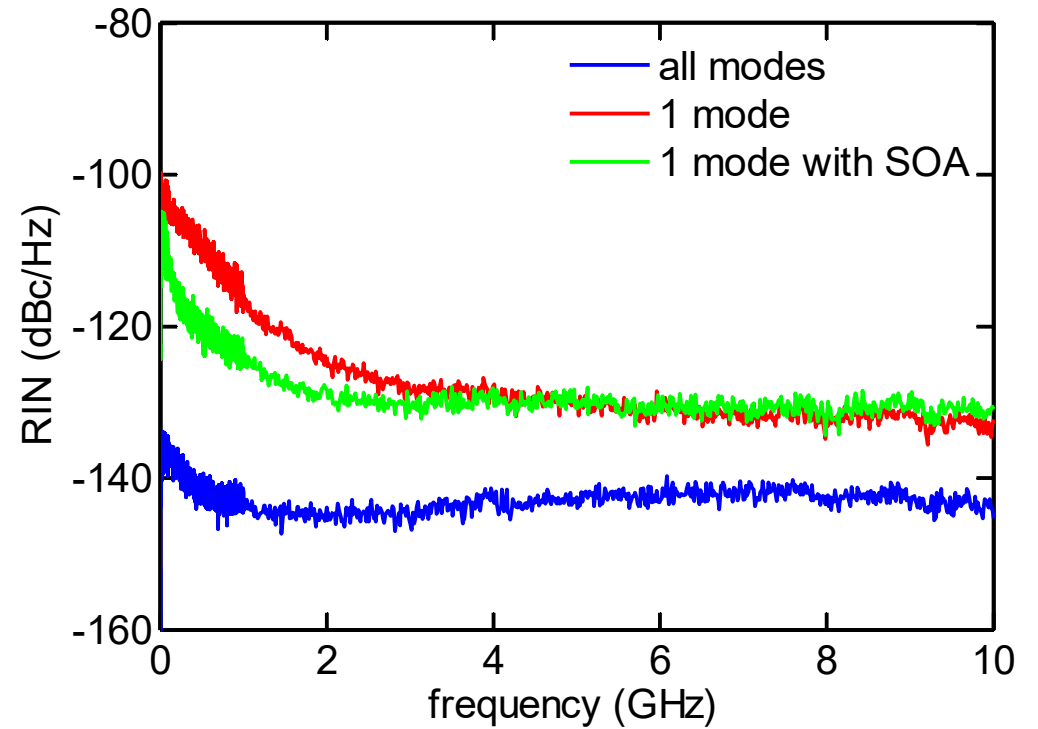
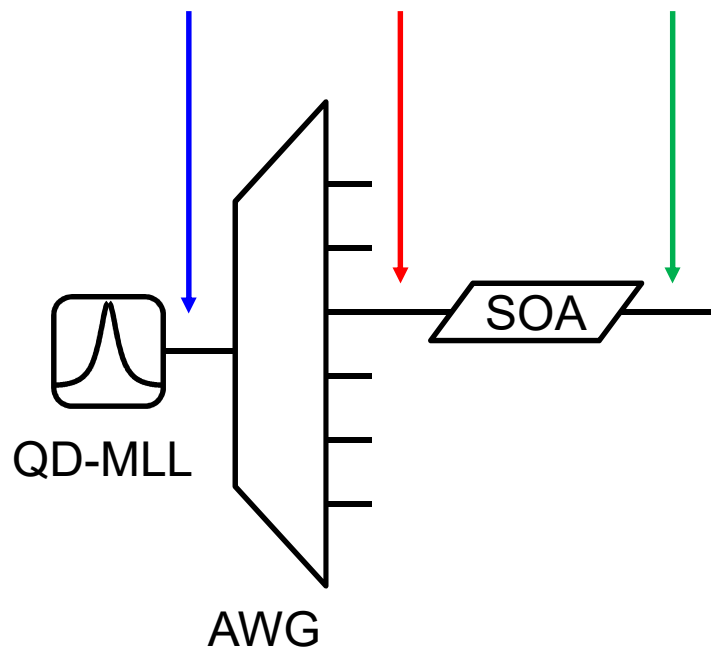
- 1 mm long InP buried heterostructure
- Commercially available
- Biased at 180 mA \Rightarrow 20 dB small signal gain and 6 dBm saturated output power



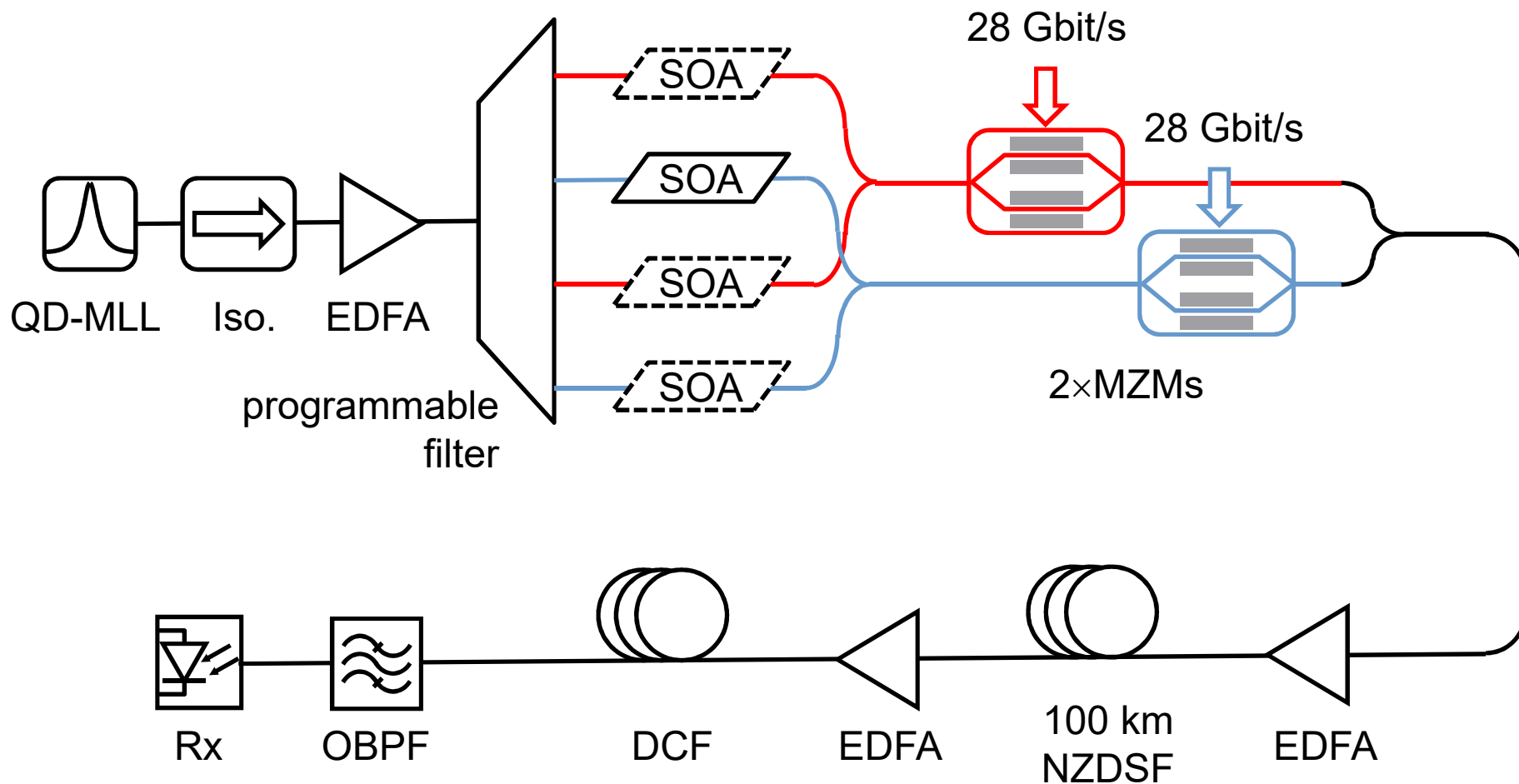
RIN below -135 dBc/Hz when all modes are detected



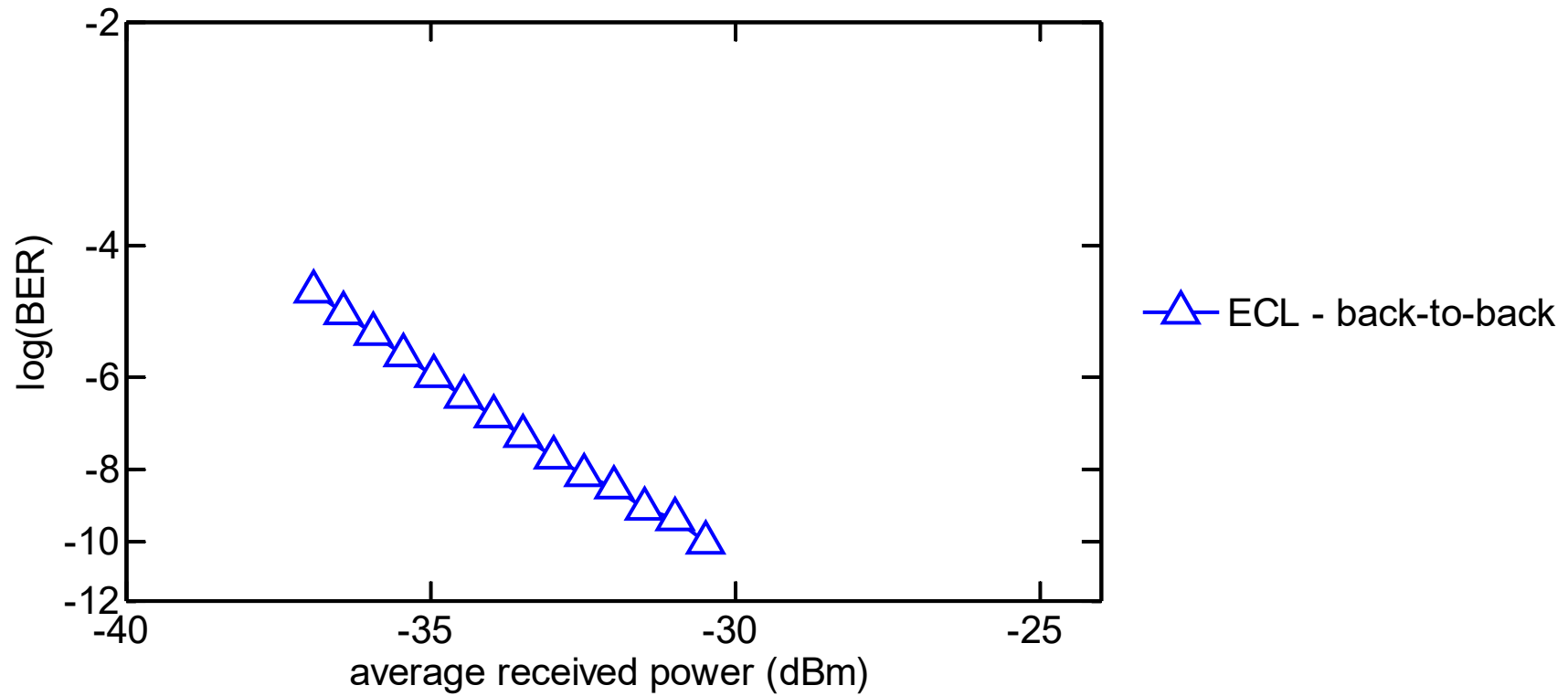
Substantial increase of RIN for single selected mode, especially at low frequencies

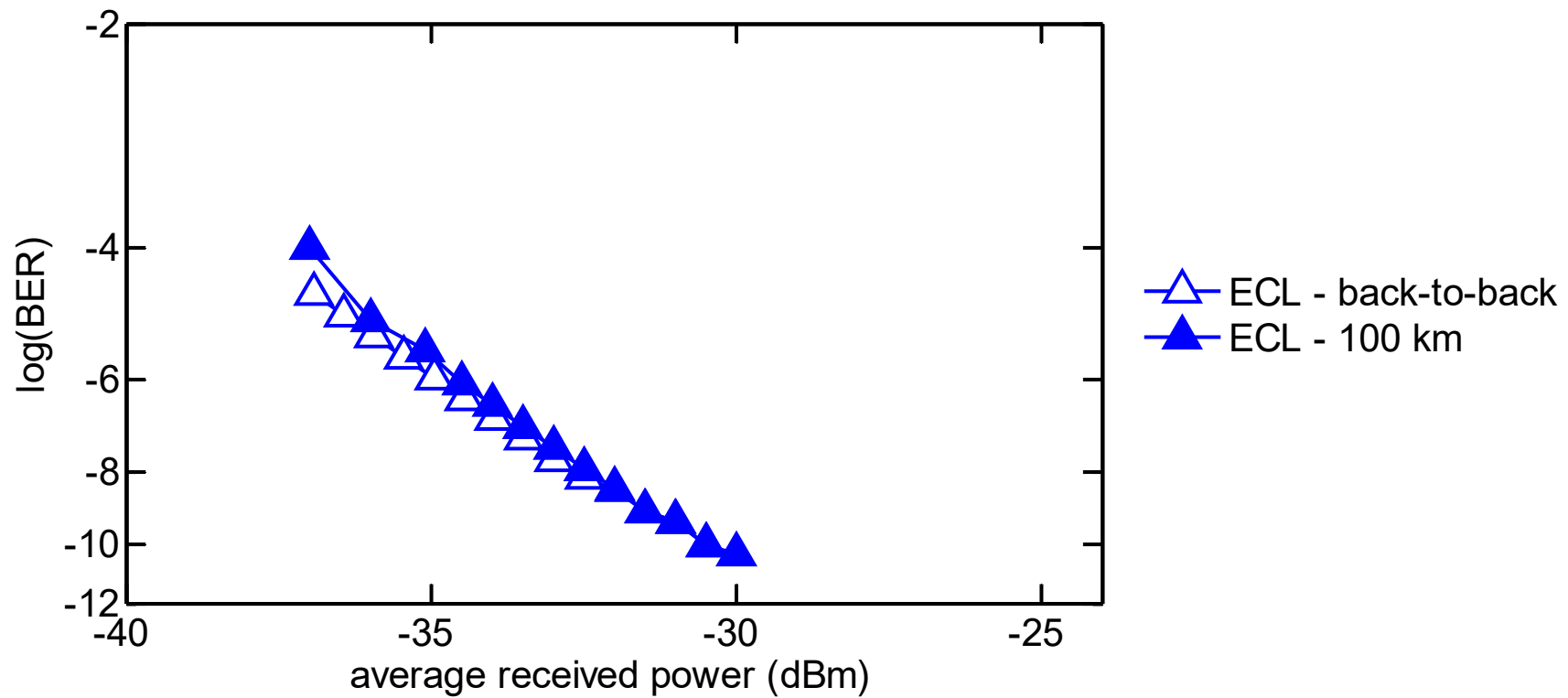


Low frequency RIN reduced after saturated SOA

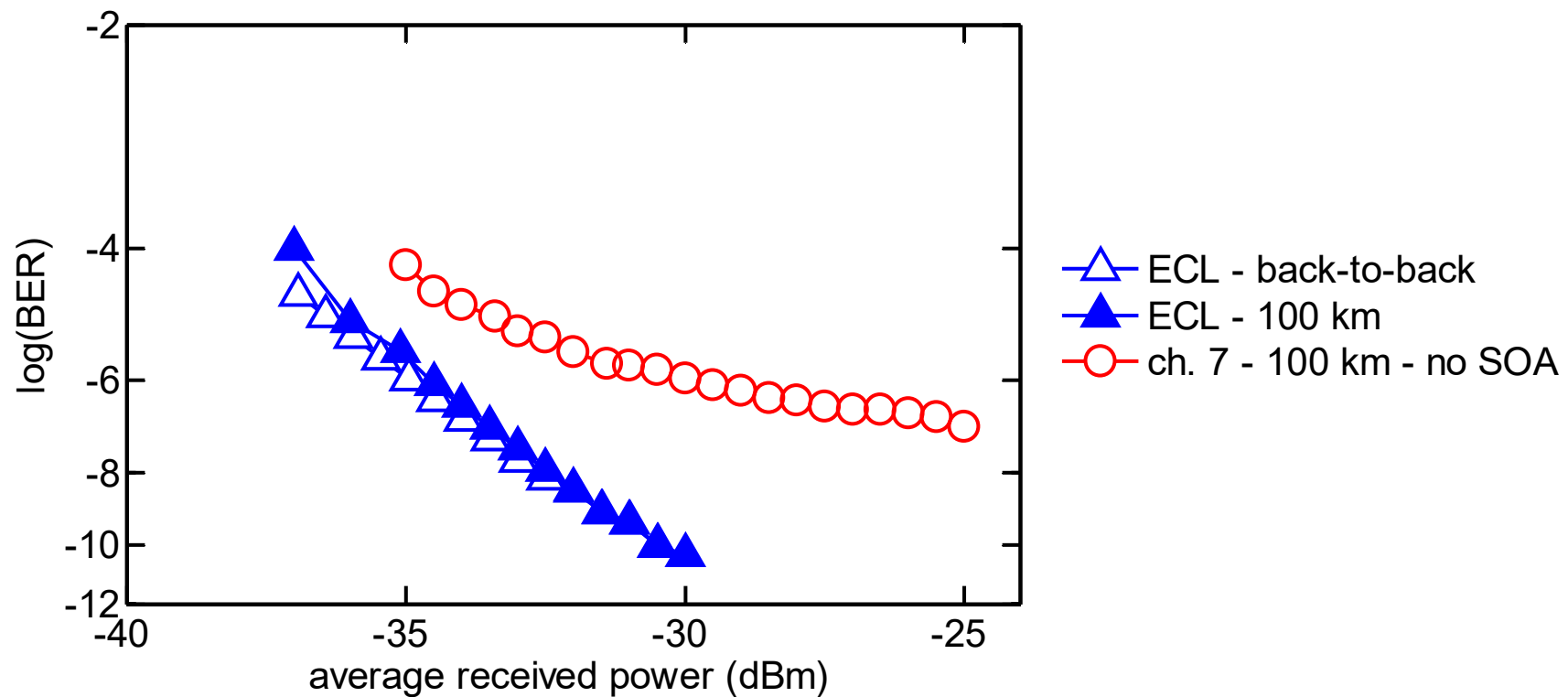


- $2^{31}-1$ PRBS
- SOA input power: -6 dBm to -3 dBm
- Gain compression: 5.5 dB to 8 dB
- 5 ps/nm/km
- 0 dBm per channel

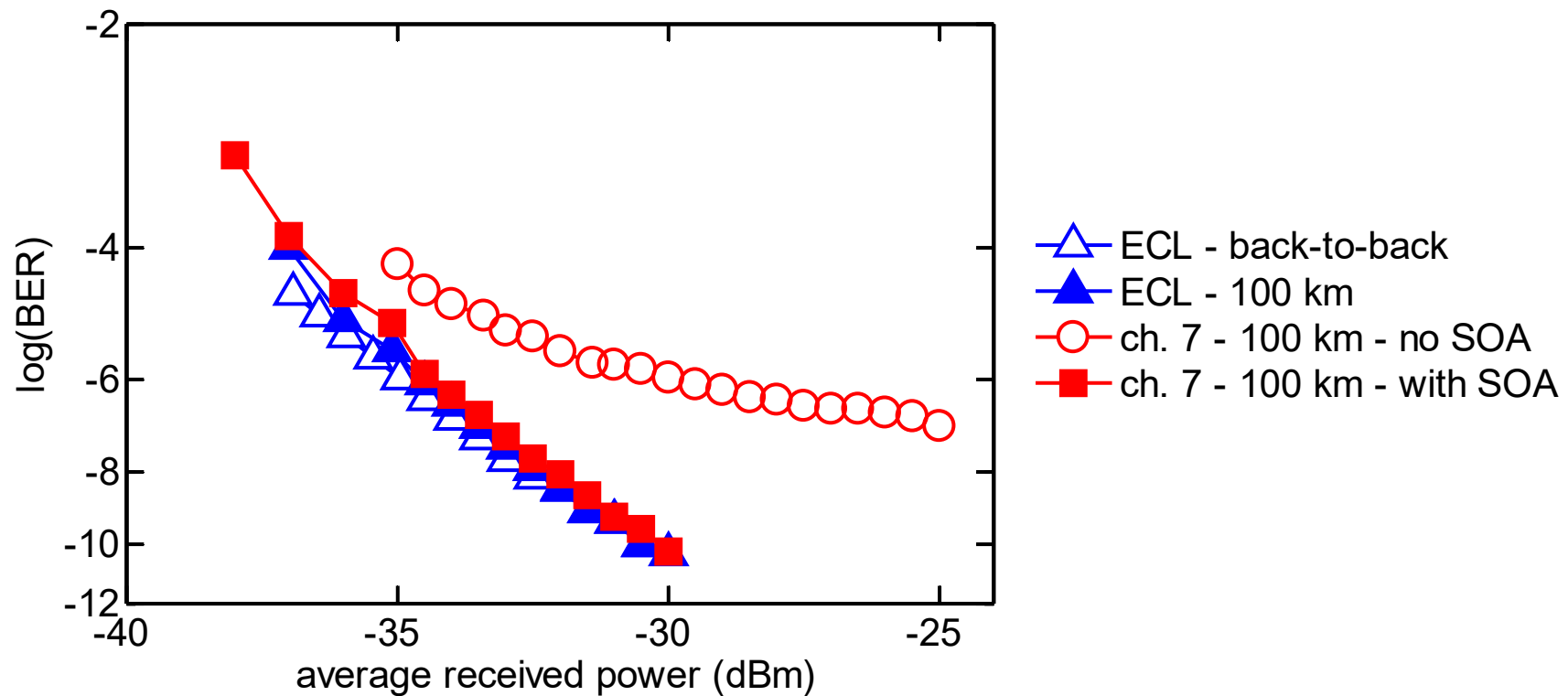




No transmission penalty if ECL is used



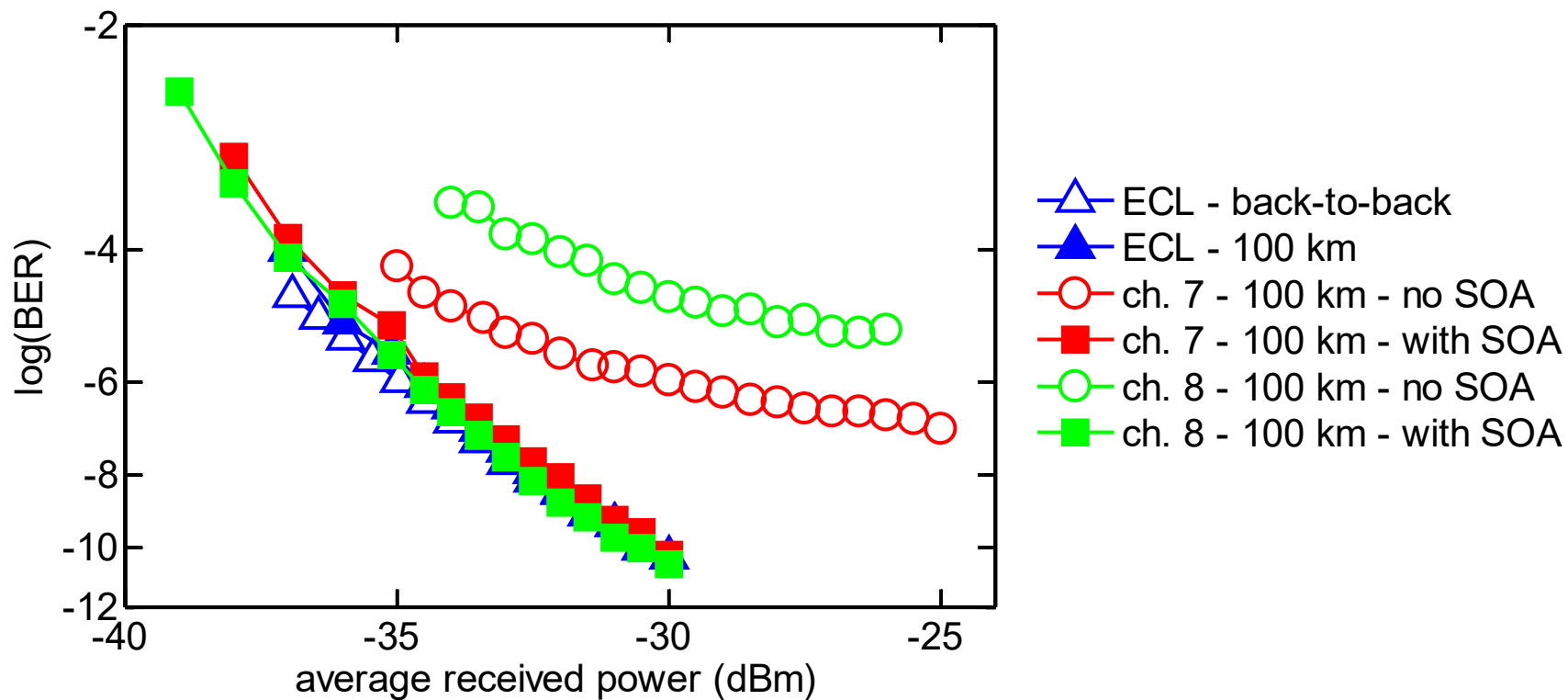
Error floor after transmission due to RIN for mode filtered from QD-MLL spectrum



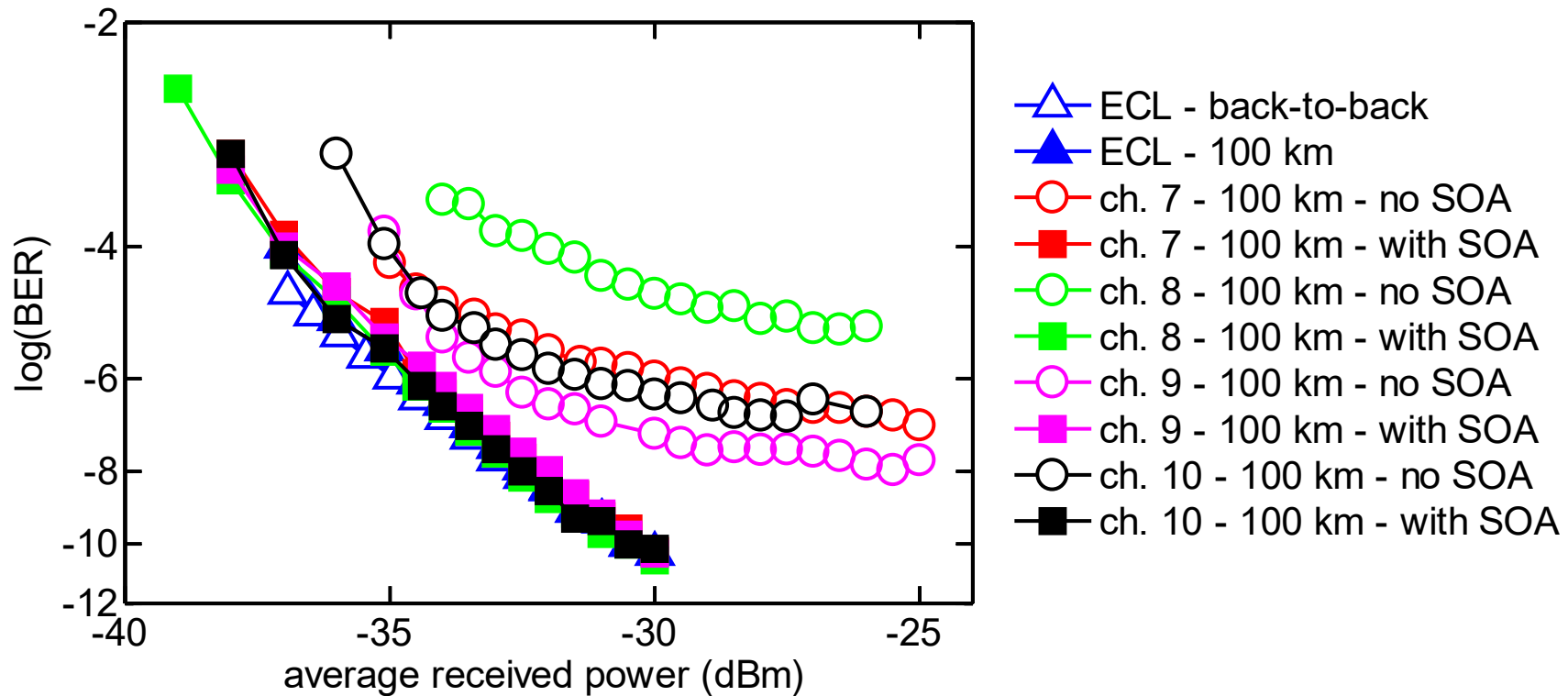
Close to back-to-back performance when the RIN of the filtered mode is reduced by a saturated SOA

BER performance

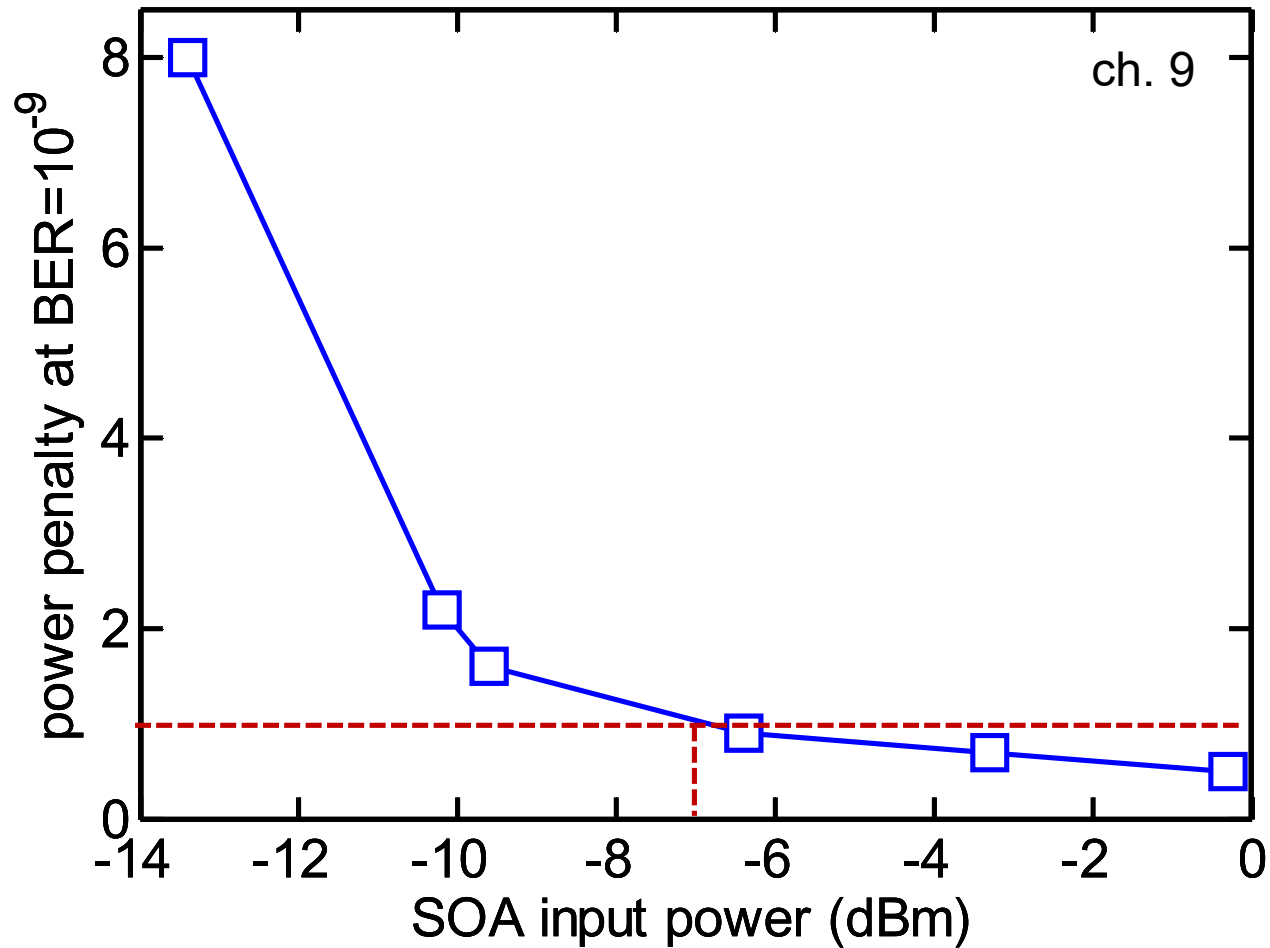
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Same behaviour for mode with even more detrimental RIN



All 4 mode channels recovered with little power penalty thanks to the use of an SOA



Less than 1 dB power penalty obtained for $P_{in} > 7$ dBm
5.5 dB gain compression

- 1) Low-frequency RIN suppression has been demonstrated in a Fabry-Perot quantum-dash mode-locked laser with 100 GHz mode separation
- 2) Relies on the use of a saturated SOA
- 3) Thanks to the RIN suppression, a 4×28 Gbit/s WDM signal could be transmitted over 100 km
- 4) Other modes expected to perform identically
⇒ transmission beyond 112 Gbit/s feasible

Potential for integration of this technique



TELDOT project
ANR-2009_VERS-12



Initial training network
PROPHET

